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THE OPEN UNIVERSITY OF SRI LANKA

FACULTY OF ENGINEERING TECHNOLOGY

DIPLOMA IN TECHNOLOGY – LEVEL 03

FINAL EXAMINATION – 2009

MEX3273 – MODELLING OF MECHATRONIC SYSTEMS

DATE : ***23 MARCH 2010***
TIME : ***0930HRS -1230HRS***
DURATION : ***THREE HOURS***

PLEASE READ THE FOLLOWING INSTRUCTIONS BEFORE ANSWERING THE PAPER

INSTRUCTIONS:

1. *This paper consists of eight questions. Answer any* ***five questions only.***
2. *Each question carries equal marks.*
3. *Answers should be written on the answer books provided by the Examinations Division.*

Question 01

(1.1) Explain the term 'Signal' in the context of modeling. Elaborate on your answer by taking suitable examples

(1.2) Why is 'signals & systems' important in modeling?

(1.3) Distinguish between a 'Discrete-time continuous-value' signal and a 'Continuous-time discrete-value' signal.

(1.4) *All memoryless systems are causal but not vise-versa*. Elaborate on this statement.

Question 02

(2.1) State the law of conservation of momentum. Hence, deduce Newton's second law of motion.

(2.2) Taking suitable examples, distinguish between 'Effort Variables' and 'Flow Variables'.

(2.3) Considering the principle of 'Effort storage element', show that the effort storage element for a mechanical system is a spring.

(2.4) Using the force-voltage analogy, show that springs connected parallel is analogous to electrical capacitors connected in a similar fashion

Question 03

(3.1) Elaborate using a suitable example, the terms 'System', 'Model', 'Input variables' and 'Output variable' in the context of System Modeling.

(3.2) Name some of the mixed (multi-domain) systems that you are familiar with and explain why it is often considered difficult in obtaining system models for such systems.

(3.3) Real systems are non-liner. However, in most cases these systems are modeled as linear systems. How is this achievable? You may take a suitable example to elaborate on your answer.

(3.4) Discuss the advantages and disadvantages of experimental modeling over analytical modeling.

Question 04

Using D'Alembert's principle or otherwise, determine the mathematical model for the system depicted in figure 04. You may take the dependent variable to be as 'x'. State all assumptions you make in answering the question.

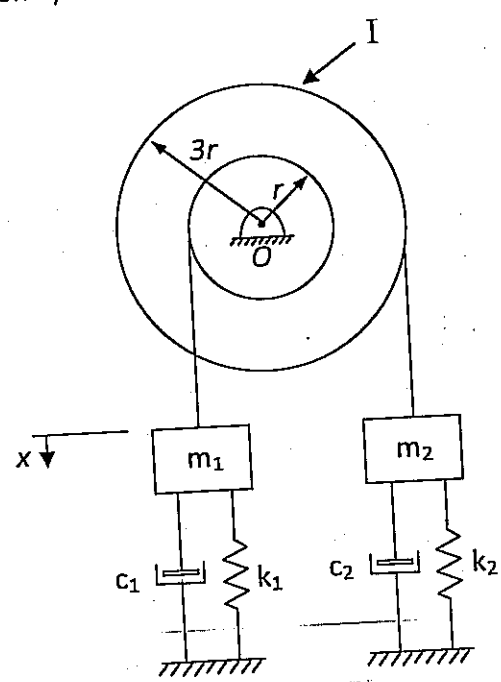


Figure 04

Question 05

Answer the following questions with regard to the electrical circuit diagram given figure 05.

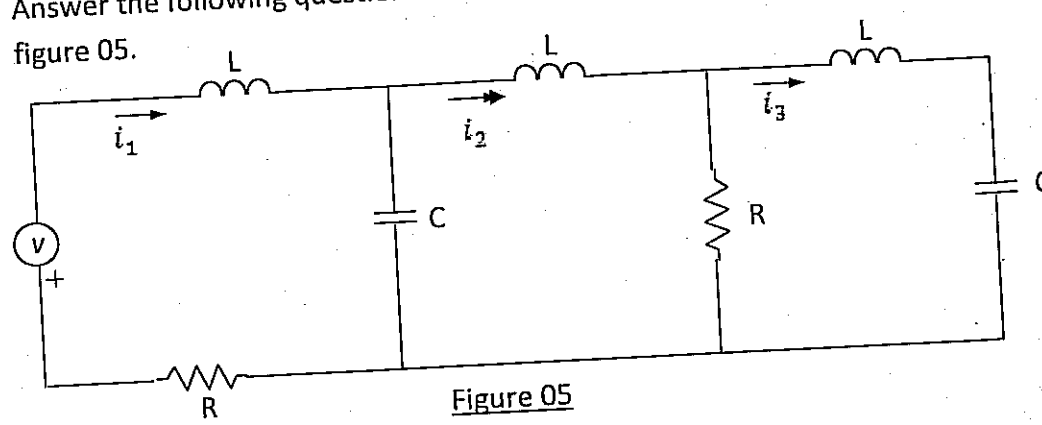


Figure 05

(5.1) Using first principles obtain the governing equations for the electrical circuit.

(5.2) Given that L=0.5H, R=3kΩ, and C=2.5μF, find $I_1(S)$, $I_2(S)$, and $I_3(S)$, if $v(t) = 100(1 - e^{-0.5t})V$ and there is no current in the circuit at t=0.

(5.3) Determine $i_3(t)$.

Question 06

(6.1) Define the term 'Mechanical Impedance', and obtain the impedances for basic mechanical elements.

(6.2) Using the impedance method find the governing equations for the system given in figure 06.

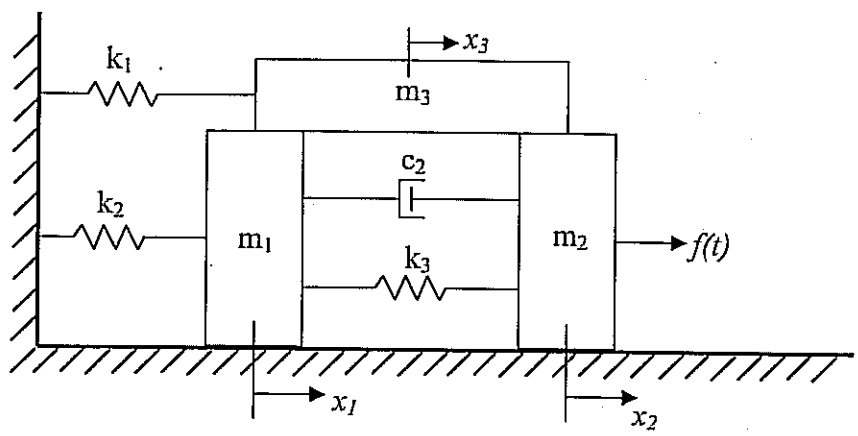


Figure 06

Question 07

(7.1) Explain the methodology adopted in converting a state-space form into a transfer function form.

(7.2) Represent the translation mechanical system given in figure 05, in state space form. You may take $f(t)$ and x_3 to be the input and output respectively.

Question 08

(8.1) Explain the advantages and disadvantages of block diagrams in system representation.

(8.2) Reduce the block diagram given in figure 06 to open loop form. You are required to show all important steps in solving question 8.2.

(8.3) Develop a signal flow graph for the block diagram in figure 06.

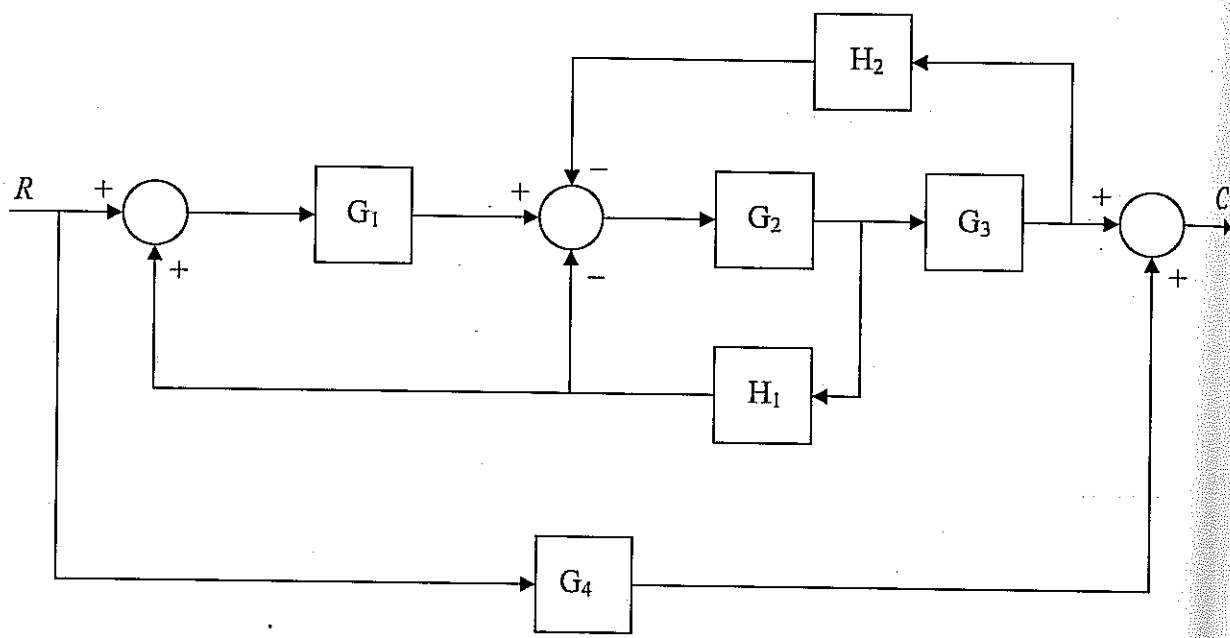


Figure 06

~ END ~

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LAPLACE TRANSFORM TABLE

f(t)	F(s)
Unit impulse $\delta(t)$	1
Unit step $u(t)$	$1/s$
t	$1/s^2$
t^n	$\frac{n!}{s^{n+1}}$
e^{-at}	$\frac{1}{s+a}$
$t\,e^{-at}$	$\frac{1}{(s+a)^2}$
$t^n\,e^{-at}$	$\frac{n!}{(s+a)^{n+1}}$
$\sin \omega t$	$\frac{\omega}{s^2+\omega^2}$
$\cos \omega t$	$\frac{s}{s^2+\omega^2}$